Quiz 162q

Name KEY

Show all work in all parts to receive maximum credit

$R = 0.0821$ L•atm/mol•K or 8.314 J/ mol•K

1) (15 points) The Jovian atmosphere contains ammonium hydrogen sulfide that decomposes according to the following equilibrium equation: $NH_4SH_{(g)} \rightleftharpoons NH_{3(g)} + H_2S_{(g)}$ **$K_p = 0.126$ at 24. °C. A 1.000 mole sample of NH_4SH is placed in a 1000. mL container and the system achieves equilibrium at some later time.**

(2) a) Write K_p in terms of the reactants and products. $\frac{P_{NH_3} \cdot P_{H_2S}}{P_{NH_4SH}} = K_p$

(1) b) Calculate K_c at 24 °C.

(4) c) Set up an I.C.E. table and calculate $[NH_4SH]_{eq}$, $[NH_3]_{eq}$, and $[H_2S]_{eq}$ in units of molarity. Be sure to check your answer.

(3) d) If the equilibrium mixture determined in **part c** is transferred to a 2.000 L container calculate a reaction quotient (Q_c) and determine which direction the reaction will shift to compensate for the change. Explain your decision. $Q_c = \frac{(0.0346_8)(0.0346_8)}{0.465_4} = 2.58_4 \times 10^{-3}$ $Q_c < K_c$ shift right

(2) e) Do you think the forward reaction is exothermic or endothermic? Explain your answer.

(1) f) If the temperature is increased will the value of K_p be larger or smaller than that at 24 °C. Explain.

b) $K_p = K_c(RT)^{\Delta n}$ $K_c = \frac{K_p}{(RT)^{2-1}} = \frac{0.126}{(0.0821 \frac{L\cdot atm}{mol\cdot K} \cdot 297 K)}$

$K_c = 5.16_7 \times 10^{-3}$

c)

	$[NH_4SH]$	$[NH_3]$	$[H_2S]$
i	1.000 M	∅	∅
c	−x	+x	+x
e	1.000−x	x	x

$\frac{x^2}{(1.000-x)} = 5.16_7 \times 10^{-3}$

$x^2 + (5.16_7 \times 10^{-3})x - 5.16_7 \times 10^{-3} = 0$

$x = -0.0745_1$ or 0.0693_5 M

$[NH_4SH]_{eq} = (1.000 - 0.0693_5)$ M $= 0.930_7$ M

$[NH_3] = [H_2S] = 0.0693_5$ M

d) $[NH_4SH]_c = \frac{0.930_7 M \times 1.000 L}{2.000 L} = 0.465_4$ M $[NH_3]_c = [H_2S]_c = \frac{0.0693_5 M}{2.000 L} \times 1.000 L$

$= 0.0346_8$ M

d.) Since volume has expanded pressure for all species will decrease. The pressure decrease is greater for the products and will lead to a $Q_c < K_c$. In order to return the system to equilibrium (K_c) the reactant gas will decompose into two gas particles to reach K_c.

e) This is a decomposition of one reactant. This will require energy to be added - endothermic

f.) $NH_4SH + \text{energy} \rightleftharpoons NH_3 + H_2S$

raising Temp increases the available energy for the reaction. Since the rxn is endothermic, the additional energy will be used to shift the equilibrium to the right permanently as long as the new temp. is maintained. Thus K_f gets larger.

2) (5 points) Determine the shift (left or right) to oppose the given change to the following equilibrium reaction:

$$2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g) \qquad \Delta H^\circ = -197\ kJ$$

a) oxygen is added — right

b) volume of reaction vessel is decreased — right

c) the pressure is increased by adding argon gas — no change

d) the temperature is decreased — right

e) sulfur dioxide gas is removed — left

3) (5 points) Given the following equilibria:

$HN_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + N_3^-(aq) \qquad K_a = 1.3 \times 10^{-5}$

$HOCl(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO^-(aq) \qquad K_a = 2.9 \times 10^{-8}$

(2) a) Determine which acid, HN_3 or HOCl, is stronger. Explain your answer. HN_3 $K_a >$ HOCl K_a

(1) b) Predict which side is favored for the following equilibrium:

$HN_{3\,(aq)} + ClO^-_{(aq)} \rightleftharpoons HOCl_{(aq)} + N_3^-{}_{(aq)}$ Right side is favored. The weak, more stable, acid is favored

(2) c) Support your answer in part b by calculating the K_c value for the equilibrium in part b.

$HN_3 + H_2O \rightleftharpoons H_3O^+ + N_3^-$ $\qquad K_a = 1.3 \times 10^{-5}$

$ClO^- + H_3O^+ \rightleftharpoons HOCl + H_2O$ $\qquad \frac{1}{K_a} = \frac{1}{2.9 \times 10^{-8}}$

$HN_3 + ClO^- \rightleftharpoons HOCl + N_3^-$

$K_c = \frac{K_{a\,HN_3}}{K_{a\,HClO}} = 4.4 \times 10^{2}$